Marvels of Modern Engineering

Steve Herrick

From the beginning, the Lab's mission has been closely intertwined with the evolution of the computer. During Herrick's time, computers were enormous, clunky, and sometimes even hazardous to your health.

When I started at Livermore in 1969 as an electronics technologist in the Electrical Engineering Department, the first computer I worked with was a Digital Equipment Corporation (DEC) PDP-1. It had less than 100 kilobytes of core memory, was dumber than the wristwatch that I wear today, and weighed more than my car.

> "It had less than 100 k of core memory, was dumber than the wristwatch that I wear today, and weighed more than my car."

This machine filled a large room in Building 117, but it had no internal operating system. All programs were fully self-contained and written in machine language. An operator ran the programs manually by entering them either from punched paper tape or IBM cards and then started the program simply by pushing a start button on the console.

In the early days, users had no way to interact with the mainframe computers directly from their offices. Users would hand write or use a typewriter to construct their data files and executables. They would then take this material to one of the teletype machines in the main computer room, usually wait in line for one to become available, and type in the information to produce punch card, paper tape, or magnetic tape files.

The first high-speed printer (pictured below) was located in the basement of Building 113. I worked on a later model which was even larger and used a Haloid-Xerox process. A marvel of modern engineering, this monster looked, sounded, and smelled like a freight train engine. It was 20 feet long and 9 feet tall. The paper was 11 inches wide and came in rolls that weighed several hundred pounds each. These were lifted into place by a hydraulic jacking device. When it ran, paper moved through the machine at 6 miles an hour. We had to fill it with toner in 5-gallon buckets and had to wear shopcoats when we worked on it.

The printing process itself was a sight to behold. The operator would climb a ladder and mount the film on top of the machine. The image from the film would be projected onto a 24-inch-wide by 18-inch-diameter electrostatic drum. As the drum turned it was showered with toner from a hopper to form a positive image. The paper continued through a fusing stage under extremely hot lamps. Finally, the paper was perforated in a guillotine-like device and fan folded for separation and distribution by an operator. Paper jams were always an exciting event because the paper in the fuser would often burst into flames, which the operator would extinguish with a blast from a high-pressure air-line.

As I compare the tools and technology of my early days to those of today, I am amazed at what was accomplished with such primitive equipment.

The first "Radiation Printer," circa 1964.

DNA and the Kangaroo Rat

Fred Hatch and Joe Mazrimas

Even for a lab that "does everything," one project in the early to mid-1970s was unusual. From its establishment in the early 1960s, the Biomedical Division did many studies of potential radiation effects on the environment. The crater from the July 1962 Sedan event at the Nevada Test Site contained moderate environmental radiation from residual radionuclides embedded in the desert sand in and around the crater. Someone suggested that we might look at kangaroo rats, which are the principal small mammals living in the area. These animals live in small territories and thus would be exposed to fixed amounts of radiation depending on the location where they were trapped.

We did not find any radiation effects, but serendipitously learned that the genus *Dipodomys*, made up of about 22 kangaroo rat species, showed many subtle differences in their anatomy permitting identification of each species. We also found fascinating differences among species in their DNA and chromosomes. The DNA could be studied by ultracentrifugation in density gradients, and stained slides were used to determine the number and structure of the chromosomes. The Biomed Division was well equipped and prepared to do these DNA studies.

We expanded the study by setting up an animal care room with the help of Barry Brunckhorst. Live traps were used on forays to NTS and all over northern California. Several additional species were provided by advisors or collaborators in western U.S. desert areas, so that we were able to examine 19 of the 22 species. For several years, the Lab had the largest collection of kangaroo rats in the country.

We found that from 3 percent to over 50 percent of the total cell DNA in different kangaroo rat species contained one or more of three simple repeated base sequences, known as satellite DNA. Other species, including mice and humans, have satellite DNA, though not in as spectacular a fashion as kangaroo rats. Satellite DNA has not yet been integrated into the concepts of the modern "genomic era."

The serendipitous discovery that kangaroo rats have this remarkable variation in cellular DNA content, chromosome number and structure, and satellite DNAs resulted in the production of 13 peer-reviewed journal articles from the Laboratory, sometimes jointly with collaborators, along with 11 other articles authored by collaborators.

Kangaroo rat.

Nova laser bay.

A Laser Thrill

Bill Warren

Nova became operational in December 1984, enabling further groundbreaking research in x-ray lasers and many other areas of laser science and technology. Ten times more powerful than Shiva, its predecessor, Nova was the world's most powerful laser at the time.

When I started at the Laboratory, the Shiva laser was nearing completion. As a computer programmer, the first decade of my work here supported the design and building of the next laser system, Nova. Just as the physical systems pushed the engineering state of the art, the design issues pushed the computational state of the art. I was privileged to help develop the computer programs used to make engineering design decisions. Because decisions were made throughout the assembly of Nova, I was still working the same code, MALAPROP, when the system was complete.

When Nova was completed in 1984, the Laboratory decided to invite high school students to the Lab to tour the facility. I volunteered to be a guide. Although I had not seen the laser or been in the building since it was in place, I thought I had learned enough from the modeling activities to explain it to students. Besides, I would get to see it. This opportunity turned out to be the thrill of a lifetime. At first, I just saw blue boxes joined by tubes, all mounted on a scaffold. But what a scaffold! It filled the laser bay, a huge room by normal standards. Then, as my mind began to sort through what it was observing, I realized I knew what I was looking at. These were the amplifiers, those were the relay filters, there was the turning mirror. Having modeled the chain, I knew it backwards and forwards. But this was real: this was that model realized at great cost and ingenuity.

As a scientific application programmer, seeing the completed Nova exemplified what my work was all about.